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Tooth Autotransplantation: Current Indications, Modern Techniques, Complications, and Considerations for Physical Activity – Narrative Review

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ul. Pomorska 251, 92-213 Łódź, Poland**Corresponding Author:**zuzia_malek@wp.pl**Abstract****Background:**

Tooth autotransplantation (ATT) is a surgical technique that involves relocating a patient's tooth from one site to another. It is a biological alternative to dental implants. It is particularly valuable in pediatric patients, as conventional osseointegrated implants are most often contraindicated until craniofacial development is complete.

Aim:

The aim of this review is to analyze current clinical indications, biological mechanisms, and the impact of digital technologies on ATT. It specifically considers the outcomes and risks associated with physically active lifestyles.

Material and methods:

This review searched the literature on electronic databases, including PubMed, using the keywords: “Autotransplantation”, “Oral surgery”, and “Sports dentistry”. Articles included randomized controlled trials, meta-analyses, and systematic reviews from 2015 to the present year.

Results:

Reported ATT success rates range from 80% to 95%, with the highest predictability in immature teeth with open apices. Most researchers found that preservation of the periodontal ligament (PDL) is essential for biological integration. Modern digital workflows, such as 3D-printed replicas, significantly reduce procedural trauma.

Conclusion:

ATT is an effective alternative to implants, offering natural proprioception and bone induction. Achieving stable long-term outcomes requires an interdisciplinary approach and postoperative restrictions, particularly regarding physical activity, to create the optimal conditions for graft healing.

Key words:

Autotransplantation, periodontal ligament, 3D planning, physical activity, dental surgery

1. Introduction

Tooth autotransplantation (ATT) is a surgical procedure that involves the relocation of an erupted, partially erupted, or unerupted tooth from one site to another within the same individual. [\(1,2\)](#) It is a biologically based treatment option for replacing missing teeth, especially in growing patients. [\(1,3,4\)](#) Although osseointegrated dental implants are considered the standard of care for single-tooth replacement in adults, they are generally contraindicated until craniofacial growth is complete, typically between 18 and 25 years of age. [\(5,6\)](#) Because implants are ankylosed to the surrounding bone, they are unable to accommodate skeletal development. This may result in infraocclusion as well as aesthetic and functional complications when placed in pediatric or adolescent patients. [\(3,7,8\)](#) ATT preserves the periodontal ligament, allowing the transplanted tooth to adapt to jaw growth, maintain physiological proprioception, and retain the alveolar process. [\(6,9\)](#)

The most important factor for a successful autotransplantation result is preserving a vital periodontal ligament (PDL). [\(10,11\)](#) The PDL contains multipotent cells that can differentiate into cementoblasts and osteoblasts. An intact and vital PDL enables the physiological integration of the transplanted tooth within the recipient site while supporting alveolar bone remodeling. [\(12–14\)](#) Modern solutions, such as cone-beam computed tomography (CBCT) and 3D-printed donor replicas (Computer-Aided Rapid Prototyping - CARP), have significantly improved the procedure. [\(15,16\)](#) These technologies allow surgeons to precisely prepare the

recipient socket before the donor tooth extraction. These technologies significantly reduce extra-oral time and minimize mechanical trauma to the PDL cells. [\(17,18\)](#)

Sports and other physical activity are the main cause of dental trauma and tooth loss in children and young adults. They are the ideal patient demographic for ATT, which makes young athletes a very significant group for this treatment. [\(5,19,20\)](#) However, the success of graft healing in this group may be altered by a highly active lifestyle. Early return to physical activity can impair the healing process and increase the risk of complications, such as ankylosis or inflammatory root resorption. [\(4,6\)](#)

Overall, the main cause of inflammatory tooth resorption is an infected tooth canal. [\(7,21\)](#) This emphasizes the importance of endodontic treatment in mature teeth and an interdisciplinary approach. [\(1,5\)](#)

2. Patient Selection and Clinical Indications

2.1. Clinical Indications for the Procedure

ATT is a versatile treatment modality with a wide range of clinical indications. [\(4,22\)](#) The most common use is to replace severely decayed, non-restorable molars or in the anterior area for traumatic tooth loss. [\(9,19\)](#) Other, less frequent indications include developmental anomalies, such as dental agenesis and impacted teeth, as well as oroantral communications, which can sometimes be closed with tooth autotransplantation or rehabilitation after tumor resection. [\(12,22,23\)](#)

2.2. Criteria for Patient Selection

Tooth autotransplantation is a promising tooth replacement option; however, its success is closely tied to proper patient selection. [\(2,10\)](#) One of the most important factors is the patient's age. [\(13,15,24\)](#) Ideally, patients should be under 20; they present good healing and bone remodeling capacities. [\(1,25\)](#) Moreover, in growing patients, the transplanted tooth is compatible with the development process and can erupt alongside the other teeth. [\(4,8,26\)](#) Another advantage of the patient's young age is the possibility of open apices in transplanted teeth. [\(19,25\)](#) Incomplete development of the tooth provides better conditions for revascularization and allows preservation of a vital tooth. [\(1,6,20\)](#) In addition, the patient must be in good general health. [\(10,27\)](#) Any uncontrolled systemic or metabolic disease is a contraindication. [\(1,22,28\)](#)

Local conditions are just as important for the healing process and treatment success. [\(6,29\)](#) The bone at the recipient site must have sufficient volume to accommodate the donor tooth. [\(2,26\)](#) The patient must maintain good oral hygiene, as plaque control is essential for preventing

periodontal attachment loss. [\(2,3,13\)](#) The oral cavity should also be free of infection or inflammation to properly support the graft. [\(6,12,30\)](#)

Tab. 1. Comparison of clinical outcomes following tooth autotransplantation in immature (open apex) and mature (closed apex) donor teeth. [\(1,10,13,20,31\)](#)

Parameter	Open apex (immature teeth)	Closed apex (mature teeth)
Survival rate	93.8–96.9%	91.4–93.0%
Clinical success rate	84.0–88.6%	86.7–90.9%
Pulp revascularization	~96% (apical diameter >1 mm)	~15%
Ankylosis	~4%	~9%
Inflammatory root resorption	~2.8%	~7.8%
10-year survival	99.8%*	87.5%

* Reported for immature autotransplanted premolars.

3. Procedure Protocol, Biological Basis, and Modern Advances

3.1. Surgical Methodology

The most important predictor of success for ATT is the preservation of the vital periodontal ligament (PDL). [\(22\)](#) Because of this, extraction of the donor tooth must be as atraumatic as possible. [\(10\)](#) Piezosurgery is often used to reduce mechanical and thermal trauma to the PDL. [\(10,32\)](#) Another factor is extra-oral time, which refers to the time the transplanted tooth spends outside of the tooth socket. It should be reduced to a minimum, ideally under one minute, since the vitality of the PDL decreases rapidly after 15-18 minutes. [\(10,12,30,33\)](#)

Another step is preparing the recipient site. The socket for the donor tooth must be slightly larger than the root. [\(4,16\)](#) The loose fit prevents mechanical damage to the PDL cells, which could cause future ankylosis. [\(10\)](#) If the tooth is being transplanted into a freshly emptied tooth socket, its shape must also be modified to fit the tooth properly. This can require reducing the intra-alveolar septum. [\(3,9\)](#)

After placing the transplanted tooth in the recipient socket, it must be stabilized adequately. Post-surgical stabilization typically involves flexible splinting for 2 to 4 weeks. [\(6,10\)](#) This allows physiological micromovement of the tooth and promotes PDL reattachment and revascularization while reducing the risk of replacement resorption. [\(3,10,34\)](#)

3.2. Pathophysiology of Tissue Healing and Regeneration

The healing process after ATT is closely related to differentiatinal properties of PDL. [\(10,26\)](#) Periodontal ligament stem cells (PDLSCs) can give rise to cementoblasts, osteoblasts, and fibroblasts, which determines the biological integration of the tooth. [\(10,22,34\)](#) In underdeveloped teeth (1/2 to 3/4 of root length) with apices over 1 mm, revascularization is possible due to the presence of stem cells from the apical papilla (SCAP) and Hertwig's epithelial root sheath (HERS). [\(1,6,13\)](#) If the revascularization succeeds (up to a 96% success rate in immature teeth), further root development and maintenance of the vital pulp are possible. [\(6,10,18\)](#) Autotransplantation promotes alveolar bone regeneration, facilitating reconstruction of the alveolar process even in areas with significant hard- and soft-tissue deficiencies. [\(8,34\)](#)

3.3. Digital Technologies. The Use of 3D Planning and CARP.

Recent advances in digital technologies, such as Cone Beam Computed Tomography (CBCT) and Computer-Aided Rapid Prototyping (CARP), have significantly improved the practice of tooth autotransplantation. [\(15,25\)](#) Procedure planning begins with a three-dimensional CBCT scan, which allows thorough assessment of the donor tooth and the recipient site. [\(10,18\)](#) Tooth morphology, the number of roots, and their positioning are evaluated for successful transplantation, as well as the amount of bone in the recipient site and precise dimensions of the alveolar ridge. [\(1,2,30\)](#) After qualifying the donor tooth, it is segmented on the CBCT scan, and with the use of specialized software, it is converted to an STL file. [\(18,27\)](#) Then, the replica of the donor tooth is produced using 3D printing or milling, depending on the preferred system. [\(1,18\)](#) Replicas used in CARP are made from biocompatible resin and are accurate up to 0,25mm. [\(10,15,16\)](#)

This approach allows surgeons to precisely prepare a neo-alveolus or customized recipient socket before the donor tooth is extracted. [\(27,31\)](#) It reduces extra-oral time of the donor tooth to a minimum, often under one minute, which is considered optimal for a successful treatment. [\(6,15\)](#) Furthermore, by using the 3D replica to shape the recipient socket, the periodontal ligament and Hertwig's epithelial root sheath are protected from mechanical, iatrogenic damage during the surgical procedure. [\(27,33\)](#) Making the procedure less traumatic to the donor tooth reduces the need for root canal treatments, especially in immature teeth. [\(15\)](#) This technology also standardizes the procedure, assisting less experienced surgeons in achieving predictable results in challenging cases. [\(25,27,33\)](#)

Tab. 2. Comparison of a 3D-assisted and conventional tooth autotransplantation [\(11,15,17,30,35\)](#)

Parameter	3D-assisted ATT (CBCT + CARP)	Conventional ATT
Overall success rate	~96.6%	Lower; generally 80–91.1%
Survival rate	95.5–100%	Comparable long-term survival
Extra-alveolar time	43–46 s (typically <1 min)	3–10 min
Total surgical time	30–45 min	40–90 min
Recipient socket preparation	Prepared before donor tooth extraction using a 3D replica	Prepared after donor tooth extraction through repeated trial fitting
Donor tooth manipulation	Minimal	Repeated insertion and removal
Risk of PDL injury	Reduced	Higher
Surgical predictability	High	Moderate

3.4. Integrated Interdisciplinary Management

Successful tooth autotransplantation depends not only on correct surgical technique but also on close interdisciplinary collaboration. [\(4,7\)](#) This approach requires coordinated work of oral surgeons, orthodontists, endodontists, and restorative dentists. [\(4,33,36\)](#) The efforts of specialists are essential to ensure that every stage of treatment is a part of a comprehensive plan. It is necessary to treat the patient holistically from initial case selection to long-term stabilization. Such a strategy improves clinical outcomes. [\(4,7,33\)](#)

Endodontics: After autotransplantation, the question arises as to whether endodontic treatment of the donor tooth is necessary. The most important factor is the root's stage of development. [\(1,10\)](#) When the transplanted tooth is mature and the apex is closed, the choice is always to perform RCT. Such teeth have no revascularization potential; their pulp undergoes necrosis following extraction. [\(1,2,10\)](#) Root canal treatment initiated within the first 2 weeks is considered optimal. [\(10,34,37\)](#) Before final root canal obturation, intracanal dressings containing calcium hydroxide or corticosteroids and antibiotics may be used to reduce the bacterial load and create favorable conditions for healing. [\(3,7\)](#) However, when transplanting immature teeth, routine RCT is contraindicated. [\(13\)](#) When the apex diameter exceeds 1 mm, the tooth can remain vital after the procedure. [\(6,9\)](#) Endodontic treatment must be performed

in three cases: clinical symptoms of pulp necrosis, such as pain, swelling, and fistula; radiological signs of periapical inflammation; or any signs of inflammatory resorption. [\(3,27,33\)](#) The lack of further root development is not an indication for endodontic treatment. [\(27\)](#)

Orthodontics: Orthodontic care is essential both before and after the procedure. [\(29,33\)](#)

Pre-surgical: Orthodontists may apply a force to the donor tooth for approximately 4 weeks before the surgery. [\(4,8\)](#) This mechanical stimulation induces PDL cell proliferation, increasing the width of the PDL space. [\(14,27\)](#) Orthodontic priming of the donor tooth allows a more atraumatic extraction, minimizing damage to the root surface and improving the graft's healing potential after the transplantation. [\(17,27\)](#)

Post-surgical: Once integrated, the donor tooth can be moved orthodontically just like natural teeth. Orthodontic treatment can safely begin 3 to 6 months after surgery. [\(3,4,33\)](#) Orthodontic treatment helps align the transplant into a functional occlusal position, further stimulating healthy bone remodeling. [\(4,36\)](#)

Periodontics: The clinical success of ATT is strongly connected to the condition of the periodontal tissues. [\(10,25,38\)](#) Regular assessment of probing pocket depth (PPD) and clinical attachment level (CAL) allows early detection of complications. Additionally, maintaining optimal oral hygiene is crucial to prevent inflammation and attachment loss. Each visit must include an oral hygiene evaluation. [\(6,10\)](#) A typical follow-up protocol involves visits at 1, 3, 6, and 12 months after transplantation. [\(1,10,39\)](#)

Conservative Dentistry and Overall Microbial Control: ATT can be performed only after eliminating any inflammatory foci and potential sources of bacterial infection within the oral cavity. [\(6,10\)](#) Strict microbial control is essential to minimize the risk of postoperative infection and enable optimal periodontal healing. [\(1,13\)](#)

3.5. Biomodulation and Tissue Engineering

Nowadays, autogenous materials are often used to improve the predictability of tooth autotransplantation. They are particularly helpful in cases of challenging bony conditions in the recipient site. The integration of blood concentrates supports the healing of both hard and soft tissues. [\(1,38\)](#)

Platelet-Rich Concentrates (PRF and PRP)

Autogenous platelet-rich preparations, such as Platelet-Rich Fibrin (PRF) and Platelet-Rich Plasma (PRP), are derived from the patient's peripheral blood. Because they are obtained from the patient, they are biocompatible and do not cause antigenic reactions. PRF forms a three-

dimensional fibrin matrix that can support platelets, leukocytes, cytokines, and circulating stem cells. [\(1,38\)](#)

The regenerative potential of the platelet-rich concentrates is based on the gradual release of growth factors. Some of the most researched are: Platelet-Derived Growth Factor (PDGF- β), Fibroblast Growth Factor (FGF), Vascular Endothelial Growth Factor (VEGF), and Transforming Growth Factor-beta 1 (TGF- β 1). [\(1,3\)](#) Whereas PRP releases the majority of its growth factors within the first 48 hours, PRF releases the biomodulators slowly. [\(1,38\)](#) PRF provides a continuous distribution of cytokines to the surrounding tissues, which supports angiogenesis and periodontal regeneration. [\(1,40\)](#) Applying PRF to the recipient site can also help revascularize the transplanted tooth and protect the root surface from resorption. [\(1,10\)](#)

Autogenous Dentin Grafts (ADG)

Autogenous Tooth Bone Grafts (ATBG) or Autogenous Dentin Grafts (ADG) are prepared from the patient's extracted, non-restorable teeth. Dentin is chemically very similar to human cortical bone, containing approximately 70% minerals (primarily hydroxyapatite) and 20% organic components (mainly type I collagen). [\(1,23\)](#)

ADG exhibits osteoconductive and osteoinductive properties. It contains Bone Morphogenetic Proteins (BMPs), such as BMP-2 and BMP-7, which stimulate the differentiation of osteoprogenitor cells. It promotes bone formation and remodeling. The ADG material is gradually resorbed and replaced by bone tissue. [\(1,23\)](#)

Material Synergy: The "Sticky Tooth" Technique

The combined application of these materials results in the formation of a sticky tooth. This process involves mixing ADG granules with injectable platelet-rich fibrin (I-PRF). This creates a biocompatible, easily manageable material. It is easier to handle during surgery, prevents the displacement of graft particles outside the prepared tooth socket, and ensures an environment enriched with growth factors directly adjacent to the donor root. [\(1\)](#)

The use of ADG combined with an advanced platelet-rich fibrin (A-PRF) membrane helps preserve alveolar ridge dimensions. [\(1,38\)](#) It is particularly important in cases with extensive bone defects caused by chronic inflammation or the extraction of impacted/reincluded teeth. [\(1,3,22\)](#) Combining surgery with tissue engineering enables predictable reconstruction of the supporting tissues and reduces the risk of complications. [\(4,39\)](#)

4. Analysis of Clinical Outcomes and Possible Complications

The outcomes of tooth autotransplantation are evaluated based on two parameters. [\(8,10\)](#) The first is the survival rate, defined as retaining a functional tooth regardless of its pulpal or

periodontal status. [\(5,10\)](#) An optimal outcome is described by the success rate. A successful ATT means no pathological signs such as resorption, ankylosis, or inflammation occur. [\(10,17,20\)](#)

4.1. Positive Outcomes

Studies have shown that autotransplantation is a predictable treatment option, with survival rates comparable to dental implants. [\(2,8\)](#)

Survival Rates: Meta-analyses prove survival rates of 96.3% in the first 4 years, 88.2% between 4–8 years, and 84.8% after 8 years. [\(5\)](#)

Success Rates: In premolars, which are often considered the "gold standard" donor teeth, 10-year success rates reach 98.0%. [\(11,20,31\)](#) The premolars are especially valued in the aesthetic zone. Molars present more surgical challenges due to complex root anatomy. Pooled success rates range from 89.4% to 92.9%. [\(13,31,41\)](#)

Teeth with an open apex have better outcomes than mature teeth. [\(2,24\)](#) Their 10-year success rates reach up to 99.8%. [\(1,31,36\)](#) This is primarily due to their high potential for pulpal revascularization and root development. [\(6,31\)](#) When it comes to mature teeth, their survival rate remains high, around 90%. Mature teeth lack the capacity for revascularization and require root canal treatment (RCT). [\(1,13,42\)](#) Their prognosis is heavily dependent on timely endodontic intervention, with the optimal time being the first two weeks post-surgery. [\(1,7,21\)](#)

4.2. Possible Complications

Complications in ATT are most frequently associated with iatrogenic damage to PDL during extraction or prolonged extra-oral time (EOT), especially over 15–18 minutes. [\(10,12\)](#)

Replacement Resorption (Ankylosis): This involves the fusion of the root directly to the alveolar bone, gradually replacing the tooth structure with osseous tissue. [\(3,6\)](#) It is more frequent in mature teeth (approximately 6.7%) than in immature ones (4.4%). [\(17\)](#) In growing patients, ankylosis leads to infraocclusion. It stops the vertical growth of the alveolar process in the transplant area. [\(3,29\)](#)

External Inflammatory Root Resorption (EIRR): It is a destructive process caused by bacteria from the root canal system. [\(1,5,6\)](#) It can be arrested by immediate endodontic treatment with the use of a temporary filling of calcium hydroxide. [\(1,10,12\)](#)

Periodontal Complications: Loss of connective tissue attachment, probing depths over 3–4 mm, or gingival recession are adverse outcomes connected to the periodontium. [\(10,41\)](#) They occur in less than 10% of cases and are strictly correlated with oral hygiene and surgical trauma. [\(4,10,37\)](#)

4.3. Considerations for Physical Activity

Tooth autotransplantation offers a unique treatment possibility for patients with an active lifestyle. [\(3,7\)](#) A specific patient group is adolescents participating in contact sports. The risk of traumatic dental injuries in this group is statistically higher; moreover, their age and probable good health make them ideal candidates for this treatment. [\(3,25,33\)](#)

Biological Advantage in Active Patients: Unlike implants, a successfully transplanted tooth has a functional PDL. [\(3,22\)](#) It acts as a natural shock absorber for both occlusal and mechanical forces. This allows better adaptation to dynamic loads during physical exertion. [\(22,34\)](#)

Management of Sports Trauma: ATT is frequently the treatment of choice for replacing incisors lost to sports injuries. [\(3\)](#) This management is particularly valued in young patients for whom implants are contraindicated due to ongoing skeletal growth. [\(4,7\)](#) It provides a biological tooth replacement that allows physiological development. [\(4,6,33\)](#)

Postoperative Prevention and Protection: Physically active patients require specific supervision during the healing phase. [\(7\)](#) Returning to full activity should be discussed with the surgeon individually and may require using custom-made mouthguards to prevent further trauma. [\(7,36\)](#)

Clinical cases have shown that protective splints can provide additional stabilization during the PDL regeneration phase. [\(36\)](#) The patient should refrain from contact sports for at least 3 months. [\(33\)](#)

As with any other patient, they need to maintain a liquid diet for at least one week and avoid chewing hard or sticky foods with the transplanted tooth for at least three months. [\(6,7,33\)](#)

Impact on Quality of Life: The success of ATT improves self-confidence and psychological comfort. It enables a stress-free return to peer activities without the stigma of an aesthetic defect. [\(25,33,36\)](#)

5. Summary and Conclusions

Tooth autotransplantation has been proven to be a biologically favorable and cost-effective treatment modality. It offers a predictable alternative to conventional prosthetic and implantological rehabilitations, particularly among adolescents. [\(2,8,25,38\)](#) Extensive clinical evidence and recent meta-analyses indicate that ATT is a predictable procedure, with survival

and success rates frequently exceeding 90%. [\(1,8,13\)](#)

The primary advantage of ATT is the preservation of a vital periodontal ligament, which maintains natural proprioception. [\(3,22\)](#) A functional tooth supports alveolar bone development and acts as a biological shock absorber. The natural damper accommodates mechanical loads during physical activity. [\(6,22,26\)](#) These physiological benefits make ATT the treatment of choice for growing patients. [\(8,9,12\)](#) In this group, rigid implants are contraindicated because of their inability to adapt to skeletal changes, which leads to infraocclusion and aesthetic complications. They also reduce the development of the alveolar bone in the area of implantation. [\(4,6,7,29\)](#)

Predictability of outcomes has been significantly improved by modern digital workflows, specifically the use of CBCT imaging and 3D-printed replicas (CARP). [\(10,11,27\)](#) These technologies allow for precise preparation of the recipient, while drastically reducing extra-oral time. This protects PDL and Hertwig's epithelial root sheath from iatrogenic trauma. [\(10,15,27\)](#) The use of tissue bioengineering advances, such as Platelet-Rich Fibrin (PRF) and Autogenous Dentin Grafts (ADG), stimulates bone regeneration. It preserves alveolar ridge dimensions, which is critical in cases with extensive bone defects. [\(1,11,38\)](#)

Clinical success depends on a synergistic interdisciplinary approach. It requires collaborative work of oral surgeons, orthodontists, endodontists, and restorative dentists. [\(4,8,33\)](#) Comprehensive care from initial case selection to long-term stabilization provides the best outcomes. [\(6,24\)](#)

In conclusion, when performed according to current evidence-based protocols, tooth autotransplantation represents a primary, biologically integrated solution that restores function and aesthetics while providing a natural replacement that harmonizes with the patient's growth. [\(7,12,26,33\)](#)

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